Collaboration Networks and Career Dynamics in Physics

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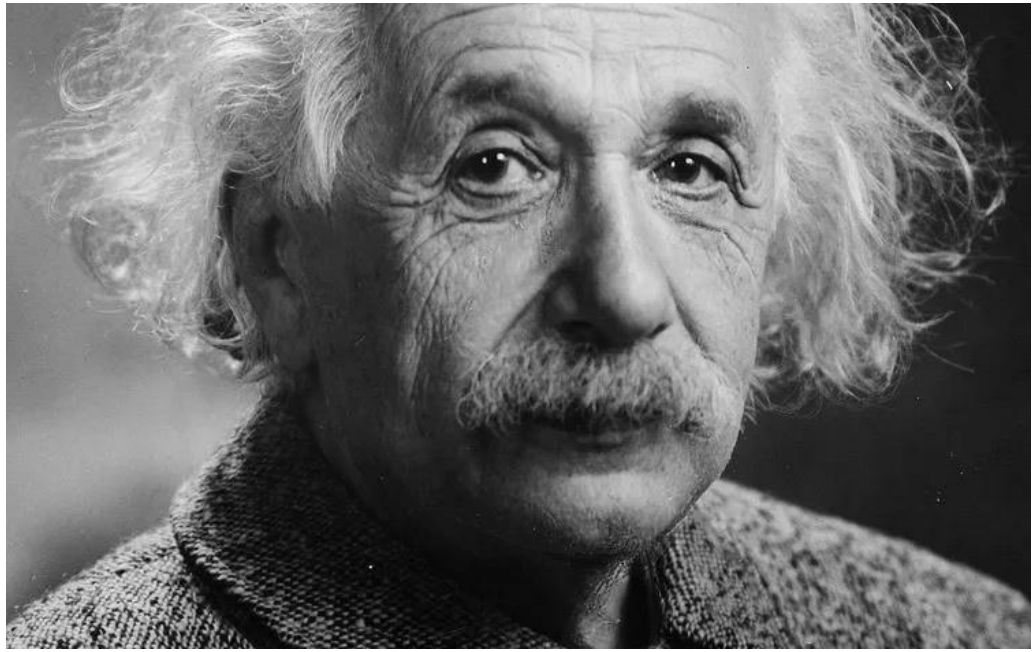
The Transformation of Collaboration in Physics



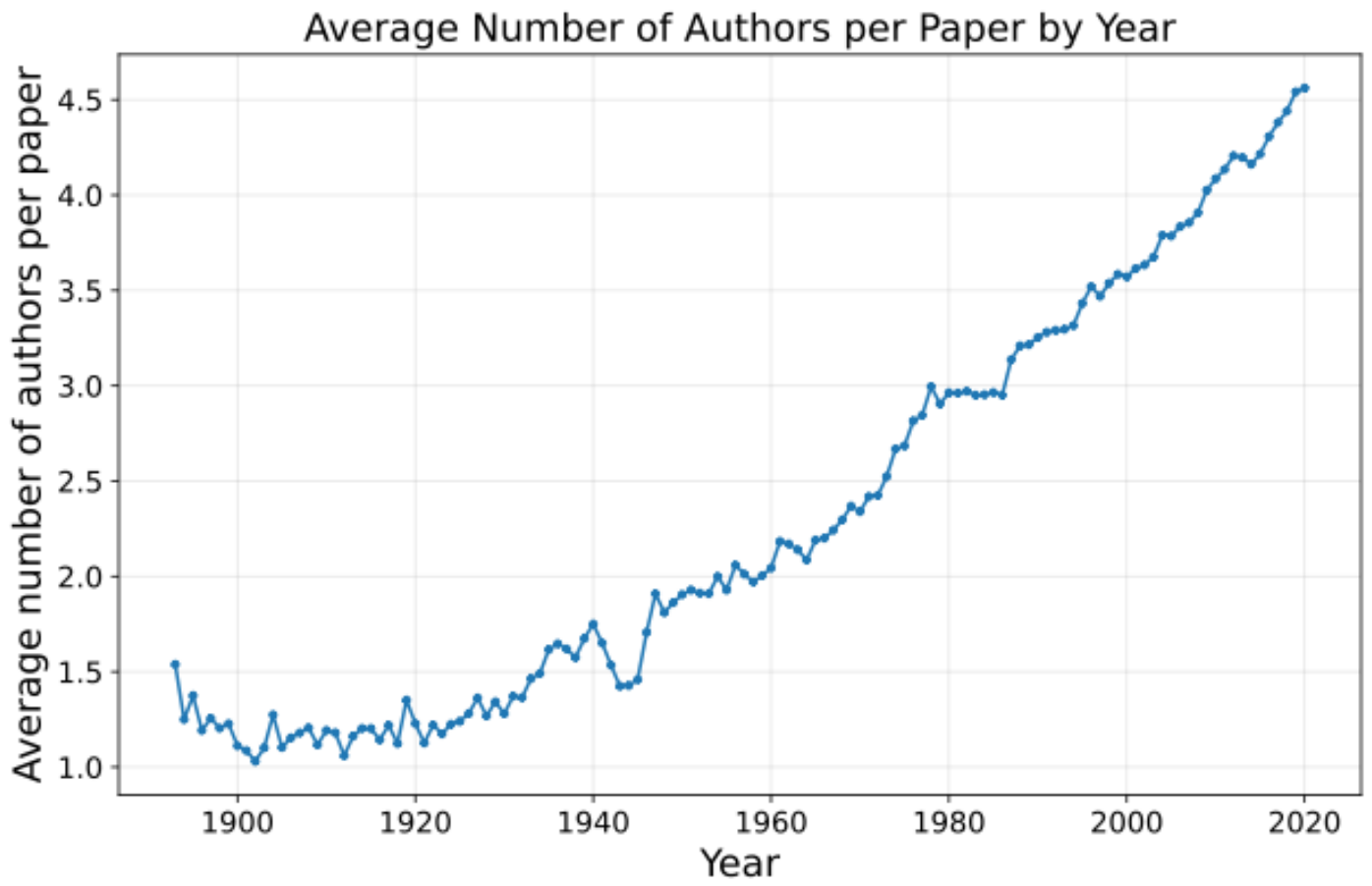
1905: Einstein working alone (1 Author)

2012: Higgs Boson Discovery (~3,000 Authors)

But does HOW you collaborate matter for your career?

The Rise of Team Science in Physics

Average authors per paper grew from under 2 in the early 1900s to over 3 by the 2000s.



Data Source: APS Physics Corpus, 1893–2020.

Two Research Parts

Exploring how collaboration shape career progression

Chapter 1

Gender & Collaboration

How does collaboration network relate to to career outcomes, and do these relationships differ by gender?

Chapter 2

Network Evolution

How do networks evolve during critical career stages, and which evolutionary trajectories associate with long-term success?

All using physics as a research setting (APS data, 1893-2020)

Chapter

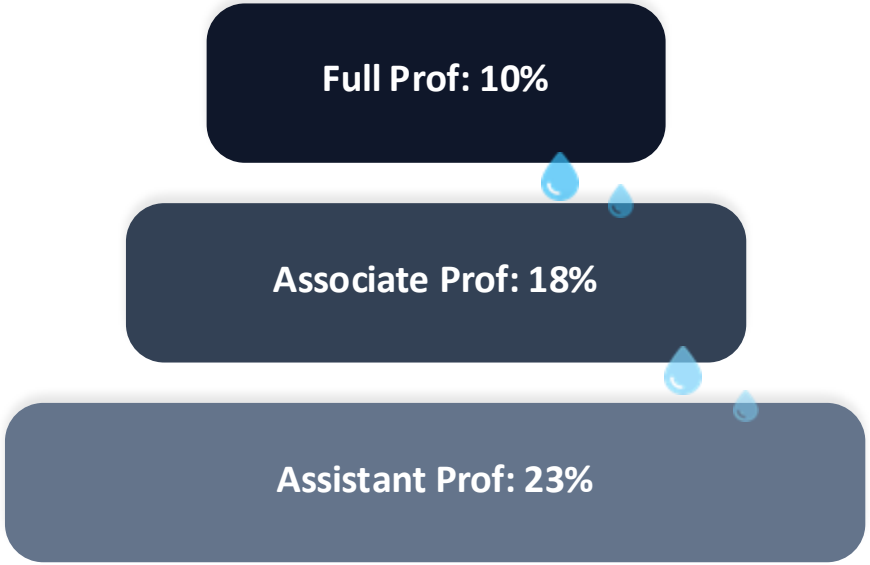
1

Gender differences in collaboration and career progression in physics

The Gender Gap in Physics

The "Leaky Pipeline"

Percentage of women across academic ranks



Source: Porter et al. (2014)

Research Setup

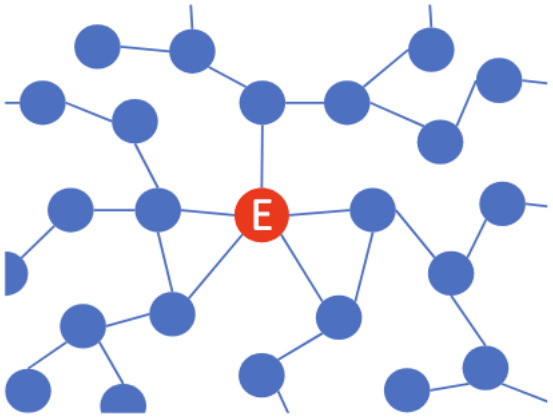
1. **Do men & women collaborate differently?**
2. **Do networks predict career success?**
3. **Does the effect vary by gender?**

Research Significance

"Understanding whether and how collaboration patterns contribute to career disparities"

Measuring Collaboration Networks

For each focal author, we constructed egocentric social networks based on the author's full list of publications and co-authors and derived four metrics:



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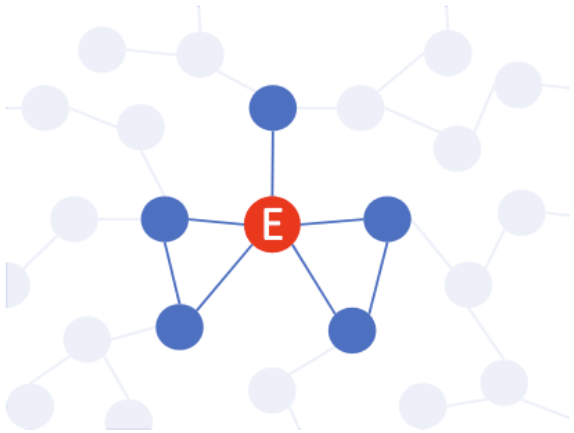


Collaboration Networks

Network size
# of unique collaborators

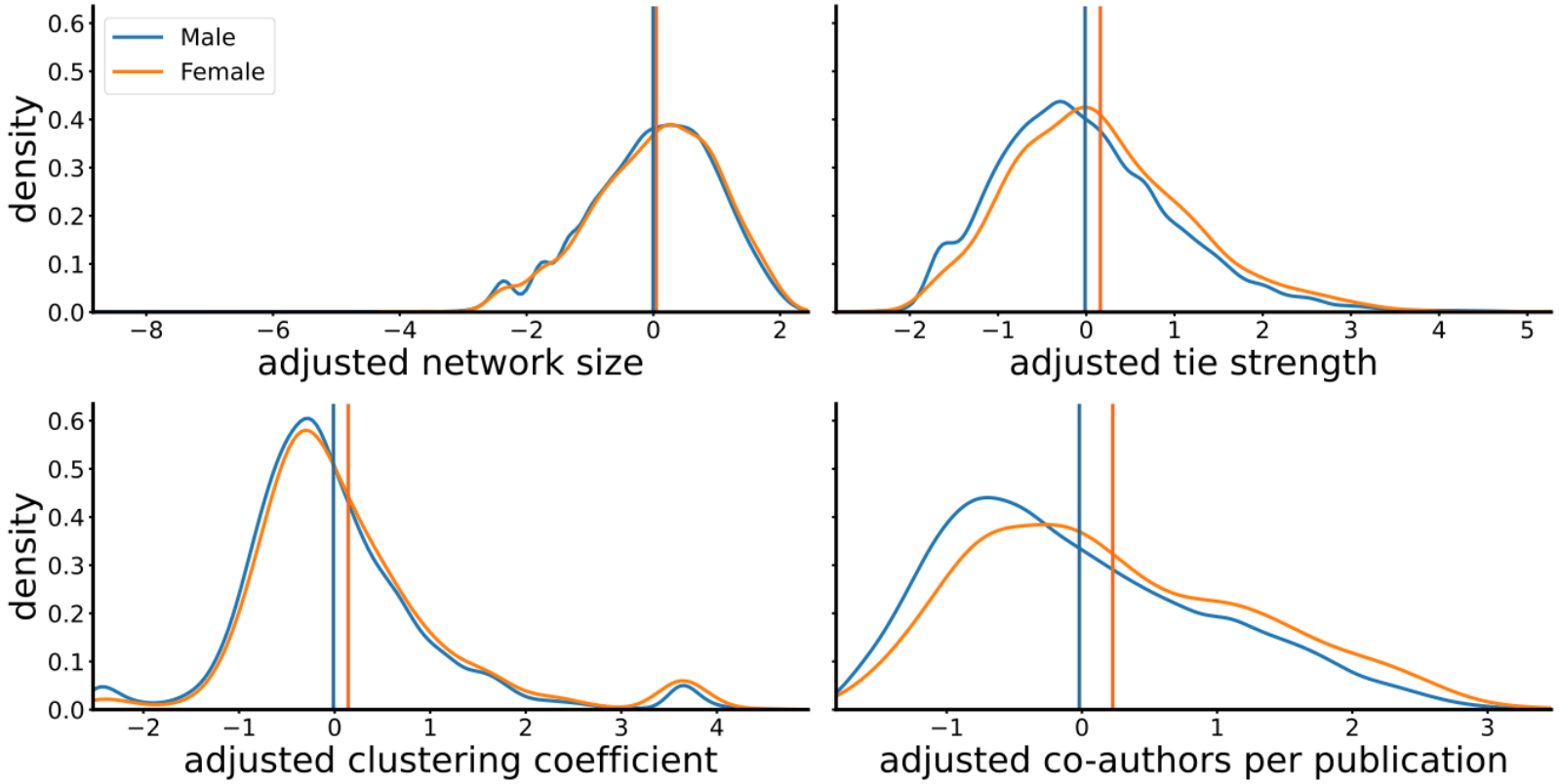
Tie strength
Freq. of repeated collabs

Clustering coefficient
Interconnectedness

Co-authors/paper
Mean # per publication

Gender differences in collaboration behavior

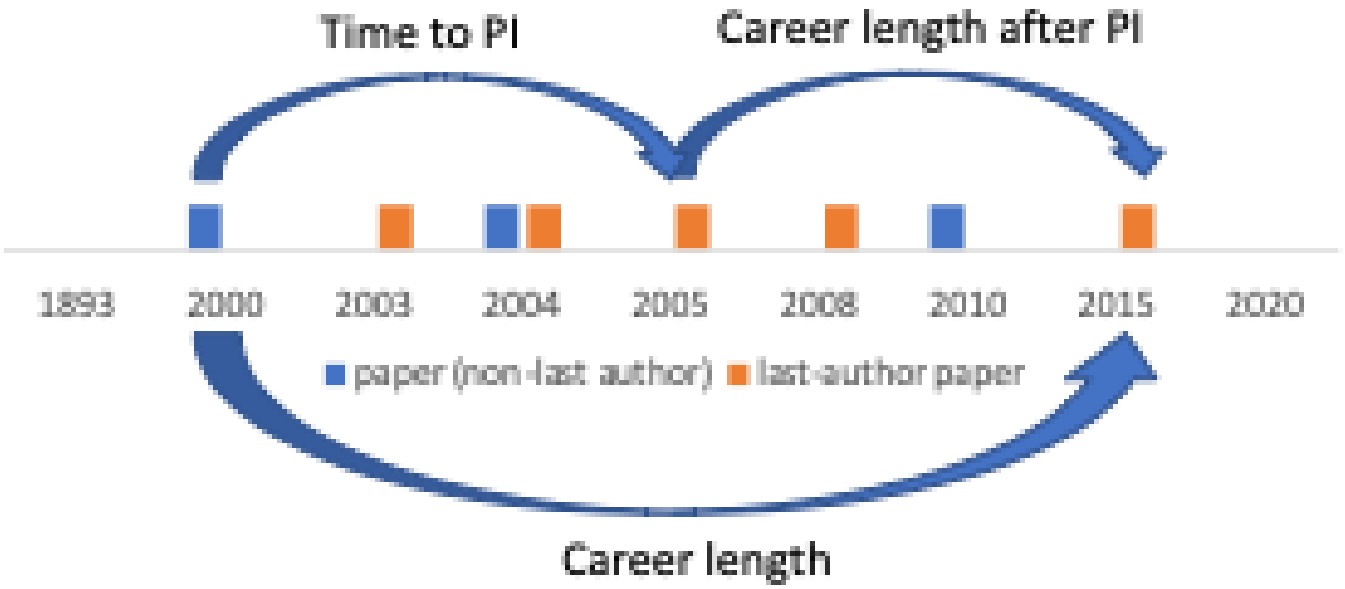
Women are found to have weaker tie strength, higher clustering coefficients, and a higher average number of co-authors per publication.

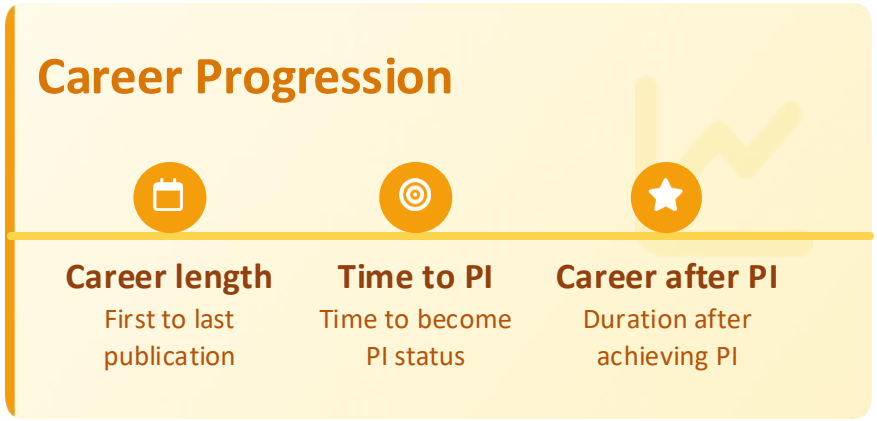


Measuring Career Progression

We measure career progression using the likelihood and time to become a principal investigator (PI), the length of an author's career, and the length after becoming a PI.

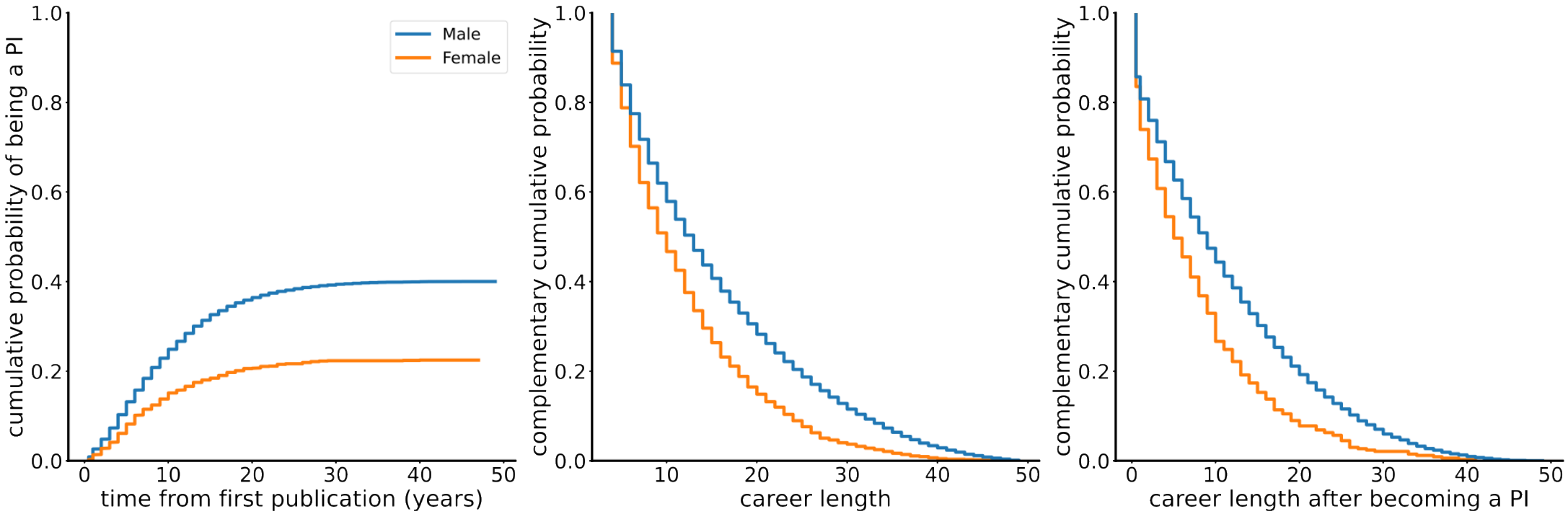
PI: Having at least 3 last-author papers



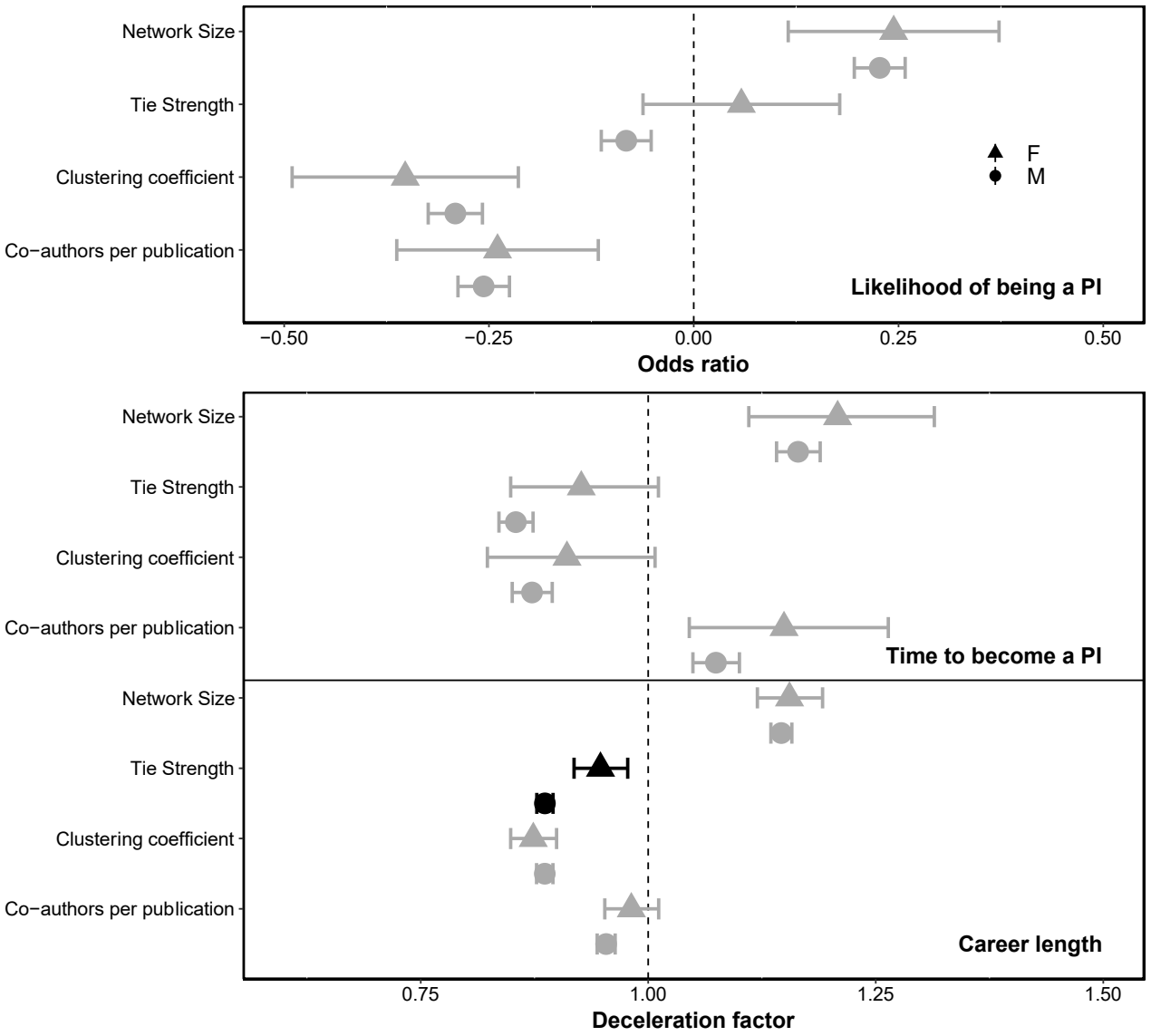


Gender differences in career progression

Women are less likely to achieve PI status and remain in academia.



Relationships between collaboration and career



Key Finding:

- ✓ **More unique collaborators** → Higher PI likelihood
- ✗ **Repeated collaborations** → Shorter career, no PI
- ✗ **Highly interconnected teams** → Shorter career, no PI
- ✗ **Larger co-author teams** → Shorter career, no PI

Women simply exhibit unfavorable patterns more frequently

Chapter

2

Academic Collaborations and Movements Towards Successful Careers in Physics

Background

Motivation

- **Collaboration networks shape academic success**
- **International mobility is seen as key for career growth**
- **Both factors change over time and interact**

Research Setup

1. How do these evolution patterns relate to **long-term academic success**?
2. How do these evolution patterns relate to **mobility**?
3. How do mobility relate to **career outcomes** within network evolution patterns?

Methodology: Time-Series Clustering

1. Sample Selection

Filter criteria:

≥15-year career
≥3 papers
>1 co-author

2. Extract Features

Extract 11-year time series of adjusted network size and clustering coefficient.

3. Time-Series Cluster

Apply Time Series K-Means to cluster authors based on career outcomes

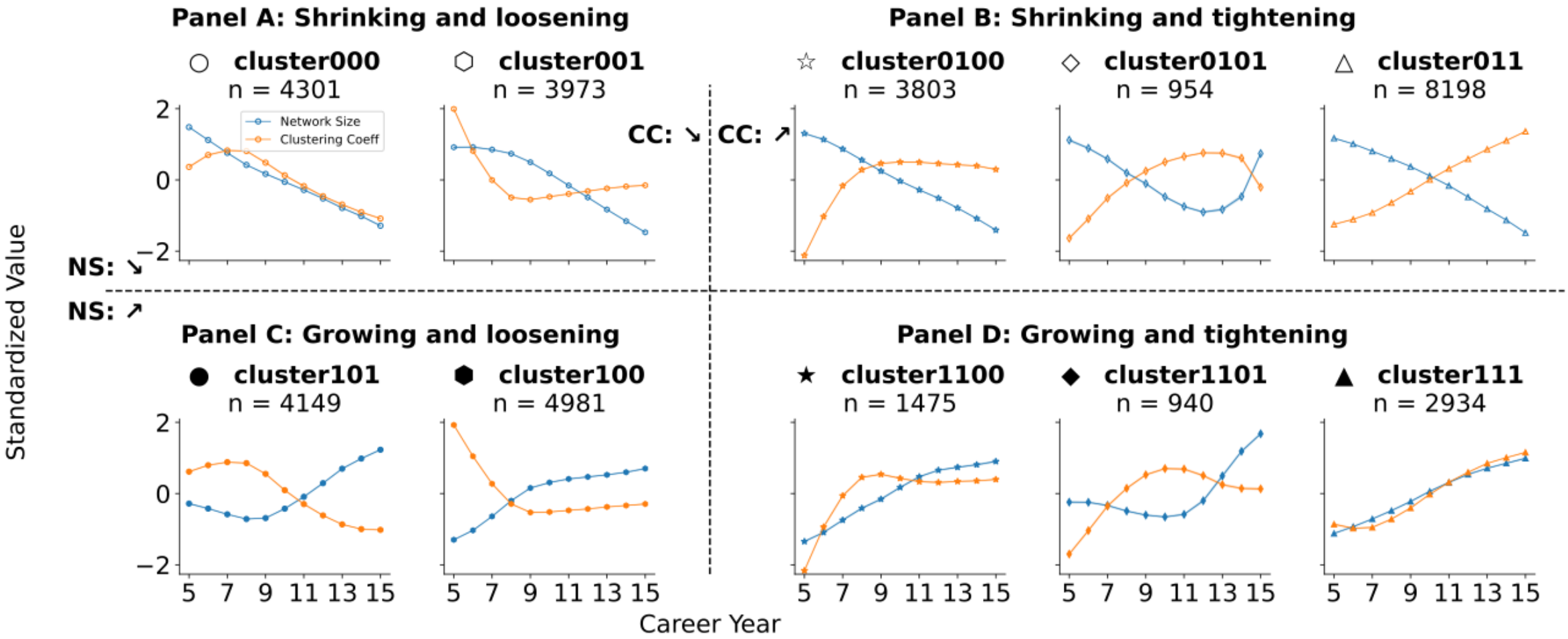
4. Evolution Patterns

10

Distinct Patterns

Categorizing dynamic career collaboration styles.

Ten Evolution Patterns



Note: "Growing/Shrinking" = relative to expected values given publication output.

Measuring Mobility & Outcomes

Mobility Metrics

Mobility Score Calculation
Quantified by the number of national affiliation changes throughout the focal period.

Early-Career Mobility
Tracked during career years 1–5.

Mid-Career Mobility
Tracked during career years 6–15.

Career Outcomes

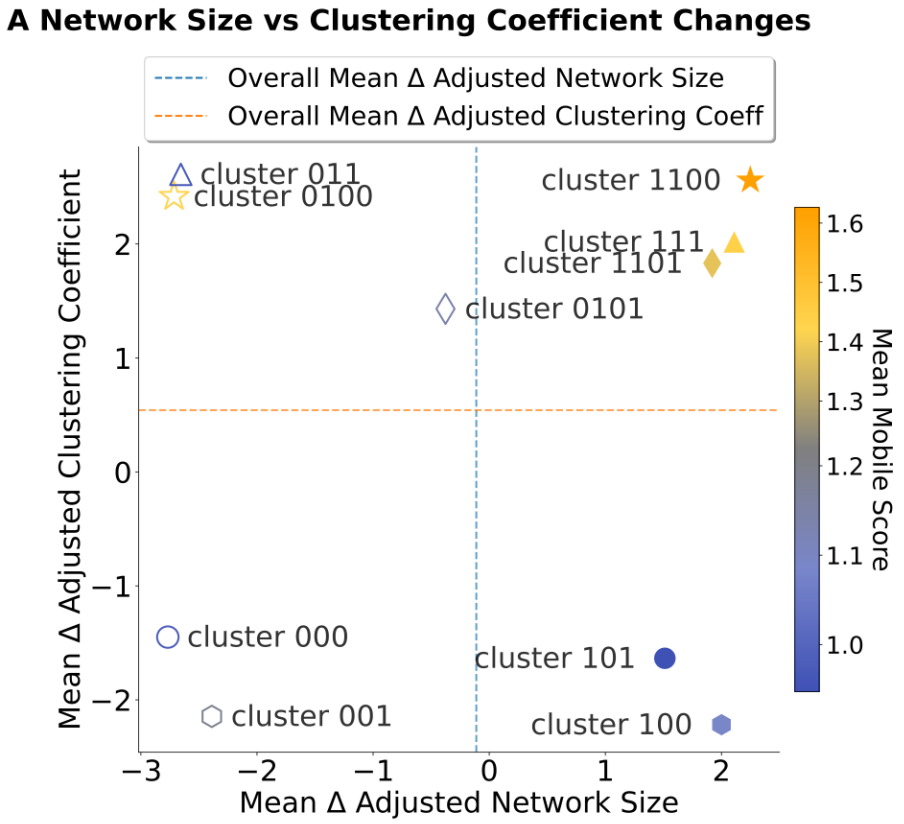
PI Attainment
Probability of becoming a Principal Investigator.

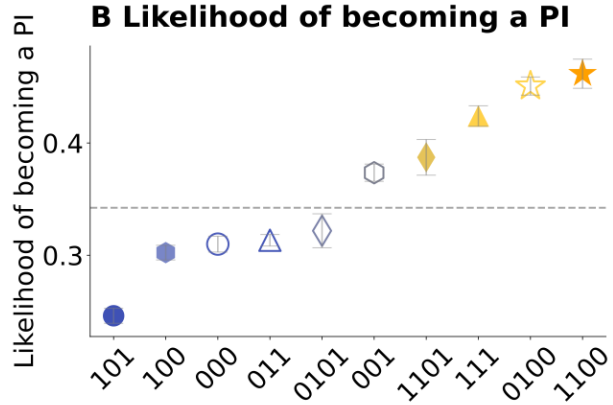
Time to PI
Duration required to reach PI status.

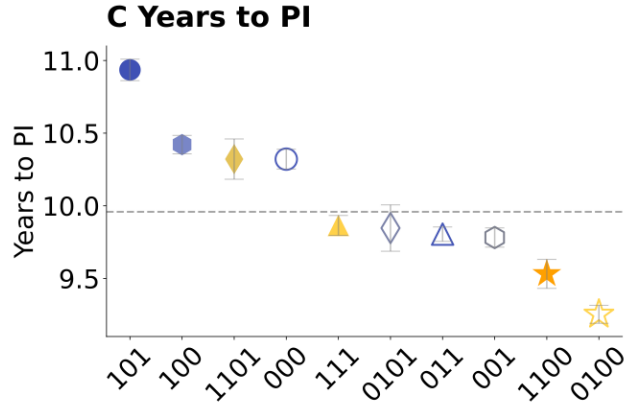
Publication Count
Total number of papers published.

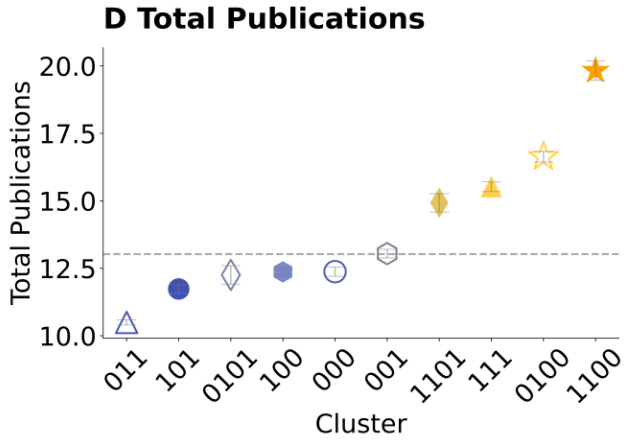
Citations per Paper
Average academic impact and recognition.

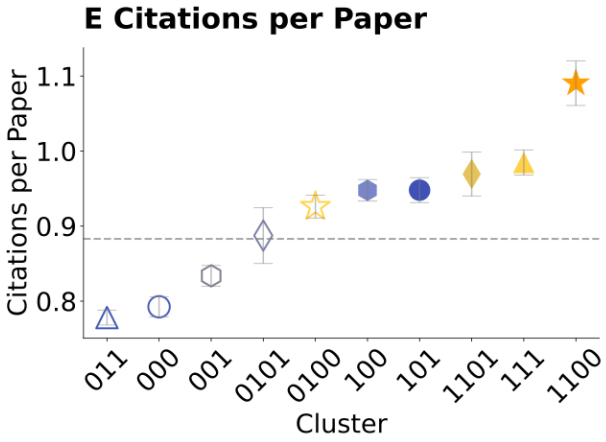
Evolution Patterns & Outcomes







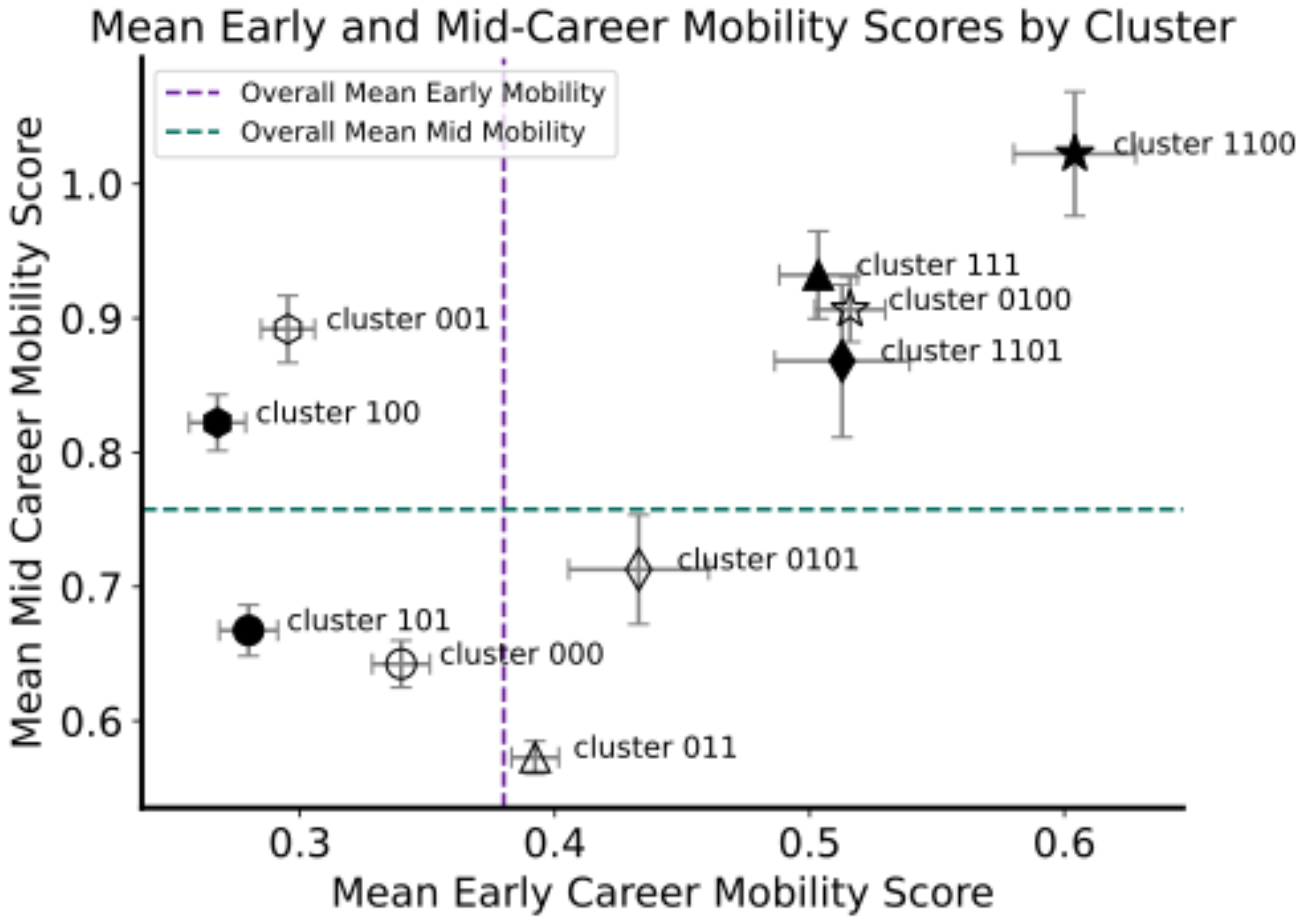




Key Findings

Growing and tightening patterns had the highest mobility scores and achieved the best outcomes

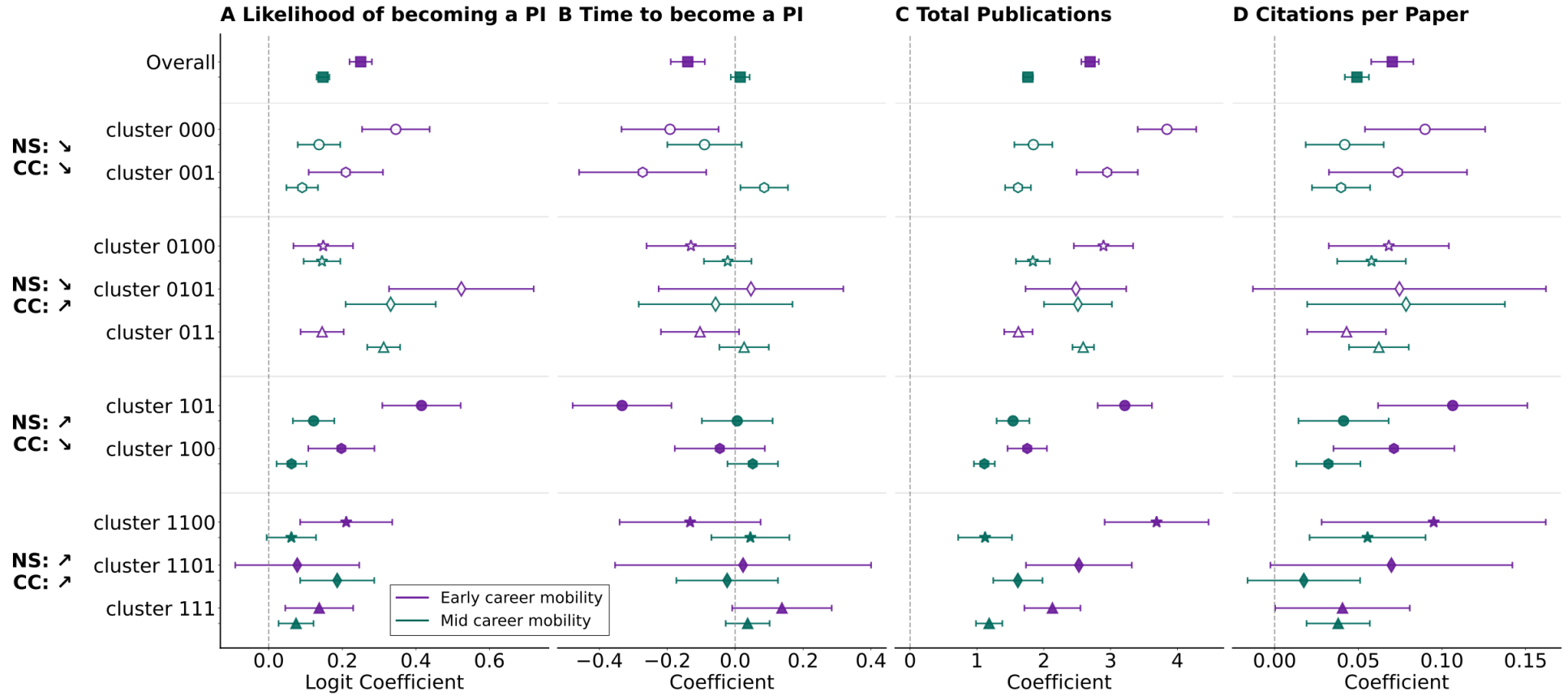
Mobility & Network Evolution



Key Findings

- Early-career mobility is negatively associated with initial network density
- Mid-career mobility is positively associated with network growth

Mobility Effects within Patterns



Key Findings

After controlling for network evolution patterns, mobility remains positively associated with outcomes

Key Findings: Network Evolution

Summary of the mechanisms driving long-term academic success in physics.

01

Optimal Trajectory

Researchers who begin with loosely connected networks and and gradually tighten them while expanding size.

Yields the highest rates of PI attainment, publication volume, and overall citation impact.

02

Role of Mobility

International mobility remains positively associated with scientific outcomes even after controlling for network evolution patterns.

Successful network evolution patterns tend to exhibit higher mobility scores.

Thank You

> *"How we collaborate shapes who we become."*

Questions?